EVALUATION OF OBTURATION QUALITY IN OVAL SHAPED CANAL USING SAF SYSTEMS AND WAVE ONE SYSTEM BY COMPUTED TOMOGRAPHY - AN *IN VITRO* STUDY

Dissertation submitted to

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CHENNAI

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation titled **"EVALUATION OF OBTURATION QUALITY IN OVAL SHAPED CANAL USING SAF SYSTEMS AND WAVE ONE SYSTEM BY COMPUTED TOMOGRAPHY - AN *IN VITRO* STUDY"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. Veni Ashok, M.D.S., Associate Professor**, Department of Conservative Dentistry and Endodontics, Ragas Dental College and Hospital, Chennai.

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CERTIFICATE

This is to certify that this dissertation titled **"EVALUATION OF OBTURATION QUALITY IN OVAL SHAPED CANAL USING SAF SYSTEMS AND WAVE ONE SYSTEM BY COMPUTED TOMOGRAPHY - AN *IN VITRO* STUDY" is** a bonafide record work done by **Dr. S. Sathish** under our guidance during his postgraduate study period between 2014 - 2017.

This dissertation is submitted to **THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY**, in partial fulfillment for the degree of **MASTER OF DENTAL SURGERY – CONSERVATIVE DENTISTRY AND ENDODONTICS, BRANCH IV**. It has not been submitted (partial or full) for the award of any other degree or diploma.

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LIST OF ABBREVIATIONS

S. NO.	ABBREVIATION	EXPANSION
1.	SAF	Self Adjusting File system
2.	WO	Wave One
3.	PGFA	Percent gutta percha filled area
4.	CT	Computed Tomography
5.	CBCT	Cone Beam Computed Tomography
6.	EDTA	Ethylene Diamine Tetra Acitic Acid
7.	NaOCl	Sodium Hypochloride
8.	CCW	Counter clock wise
9.	CW	clockwise

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Introduction

INTRODUCTION

Successful endodontic treatment is based on the sound principles of debridement, disinfection and obturation[67]. Cleaning and shaping of root canals is one of the main steps in achieving endodontic success. It includes removal of vital and necrotic tissues along with infected root dentin, which gives the canal system a shape that allows easy debridement and placement of medicaments and permanent root filling of high technical quality[37]. To achieve this goal, clinicians must have adequate knowledge of root canal anatomy of the relevant tooth and its common variations.

Latrou[32] classified root canals depending on the cross-section shape as: laminar or tubular (Latrou 1980). Laminar canals can be further divided into semilunar, 'figure of 8' or straight, whilst tubular canals may be circular, triangular or oval.[30]

Metrically Jou*et al.*[31] (2004) defined ''oval'' shape as having a maximum diameter of up to two times greater than the minimum diameter and ''long oval'' as having a maximum diameter of two to four times greater than the minimum diameter. A high prevalence of oval and long oval root canals found in mandibular incisors and maxillary second premolars[32]

For many years, it has been a common practice to enlarge the root canal to at least three ISO sizes larger than the first file to bind at the apical part of the canal. It was assumed that such preparation will remove the inner layers of the dentin while allowing the irrigant to reach the entire length of the root canal for a thorough cleaning and disinfection of the root canal space[40].

Oval or ribbon shaped canals occur in approximately 25% of teeth. The preparation and obturation of these canals pose a challenge. The extremities are often untouched by instruments, whether prepared by hand or rotary instrumentation or with the use of specifically designed devices[41]

Different instrumentation techniques have been described to prepare oval canals. These include the use of sonic and ultrasonic instruments, manual instrumentation [or] the use of rotary nickel-titanium (Ni-Ti) instrumentation techniques and finally reciprocating instrumentation techniques[41].

The cutting efficiency and cleaning ability of root canal instruments are dependent on the particular instrument design as well as the dynamics used during instrumentation[40].

In this respect, there are some differences amongst the configurations of the instruments. Instruments having a non-square cross-section are generally more

efficient during cleaning and shaping than those having a square cross-sectional design.

Rotary files have superior elasticity, can preserve the location of the root canal axis, thus largely prevents transportation and ledging. When operated in oval shaped root canals, rotary nickel-titanium files may result in uneven thickness of the remaining dentin wall. The uneven thickness of the remaining dentin wall may be predisposing factor for vertical root fracture[24].

The WaveOne file system is a reciprocating system that includes 3 instruments with an apical concave triangular cross-section and reverse cutting blades. These instruments were specifically designed to minimize the risk of instrument fracture and oscillate at approximately 350rpm with30clockwise and 150 counterclockwise rotation angles[23.]

To overcome the inherent problems of nickel-titanium instruments , the Self Adjusting File (SAF) was developed .The self adjusting file (SAF) is a hollow file designed as a compressible ,thin- walled pointed cylinder either 1.5 or 2.0mm in diameter composed of nickel-titanium alloy . Adaptation to the canal walls is possible even in flat oval canals. [37.]

Obturation of irregularly-shaped canals is more challenging compared with canals with a round cross section. Cold lateral compaction is a common method for obturation, the technique can be used in most clinical situations and provides for predictable length control during compaction. Standard cones generally have a less taper when compared with non standard cones and will permit deeper spreader penetration which will result in a better quality seal. [67]

Warm thermoplastic technique have the advantages of producing plasticized gutta-percha within the obturated root canal system, resulting in a more homogenous mass of gutta-percha, and filling in irregularities. The process of heating the guttapercha outside the tooth, injecting material into the canal and accessory canals proves to be better than lateral compaction.[68]

The improvement in digital imaging technologies have paved way to assess the obturation quality of the root canal. Computed Tomography (CT) is an imaging technique where digital geometry processing can be used to generate a 3D-image of tissue and structures obtained from a large series of 2D X-ray images. X-ray scans furnish detailed images of an object such as dimensions, shape, internal defects and density for diagnostic and research purposes.[16]

Computed tomographic images were useful in differential diagnosis ,Evaluation of anatomy and complex morphology, Dentoalveolar trauma, Internal and external root resoption, Presurgical case planning, Access the quality of the endodontic obturation and treatment out come[67].

This study was done to evaluate the quality of the cleaning and shaping ability in the oval shaped canals using self adjusting file system(SAF) and Wave One system also the obturating quality using cold lateral compaction and thermoplastized obturation techniques with the help of computed tomography.

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Aim and Objectives

AIM AND OBJECTIVES

AIM:

Aim of this study was to evaluate the obturation quality of oval shaped root canals with two rotary file system (Self Adjusting File system and Wave-One system) and evaluated by computed tomographic study.

OBJECTIVE:

1. To evaluate the cleaning and shaping ability of SAF system and Wave One system in oval shaped root canals.
2. To evaluate the obturation quality in oval shaped canals with two different obturation system namely cold lateral compaction and thermoplastized obturation technique by computed tomographic study.

Review of Literature

REVIEW OF LITERATURE

M-K. Wu et al (March 2000)[60] studied the existence and the quality of obturation of uninstrumented recesses in oval canals. The balanced force technique was used in two groups of oval canals in human mandibular incisors. The canals in group 1 were enlarged to conventional sizes, whereas canals in group 2 were enlarged more widely. All canals were obturated with cold laterally condensed gutta-percha. Two horizontal sections were cut in the apical portion of each filled root. Images of the cross-sections were scanned and analysed using the KS100 Imaging system. Uninstrumented recesses appeared in 13 (65%) oval canals. The recesses in five of these 13 canals were obturated without visible voids. The recesses in the other eight canals were either obturated with visible voids or completely unfilled. They concluded that the Uninstrumented recesses may be left in many oval canals after preparation using the balanced force technique and these recesses may often not be completely obturated with cold laterally condensed gutta-percha.

M.-K.W et al (November 2002)[61] evaluated the capability of two hand instrumentation techniques, namely balanced force and circumferential filing to remove the inner layer of dentine in oval canals. Thirty mandibular incisors with a single oval canal were selected and divided into two equal groups on the basis of their radiographic bucco-lingual internal diameters measured at a level 5 mm from the apex. Two different hand instrumentation

techniques, i.e. balanced force and circumferential filing, were used in each group. The two images of the root cross-section before and after instrumentation were superimposed on one another. In oval canals, both the balanced force and circumferential filing techniques left large portions of the canal wall uninstrumented.

Nicola M et al (2007)[68] assessed whether the shaping of oval-shaped root canals by Ni- ti rotary and stainless reciprocating file using 2 different preparation techniques resulted in significant morphologic differences, forty lower premolars with oval-shaped root canals were divided into group A, instrumented with the Anatomic Endodontic Technology (AET) system, and group B, treated with ProTaper instruments. A modified Bramante technique was used to analyze changes in root canal diameters (_D), changes in surface area (_A), and the change in buccolingual and mesiodistal The 2 techniques produced a significant difference in the ultimate shape of the coronal and middle portions of oval-shaped root canals, with the AET system removing more tooth structure at these levels. Finally, they concluded that no differences were observed at the apical third.

A. ElAyouti et al (August 2008)[19] studied the efficacy of rotary instruments with greater taper in preparing oval root canals to compare the preparation quality of two rotarysystems and NiTi-hand files in oval root canals, and to evaluate the effect of canal dimensions on the preparation. Ninety roots with oval root canals were selected. The middle third was cross

sectioned at two levels and photographed. Teeth were distributed in three groups(n = 30) using stratified randomization, and prepared under simulated clinical conditions with Mtwo, ProTaper,or NiTi-hand files. The pre- and post-preparation photographs were traced and superimposed, the thickness of dentine removed was measured and the ratio of prepared canal outline was calculated. They concluded that instrumentation technique was able to circumferentially prepare the oval outline of root canals. Nevertheless, instruments with greater taper (ProTaper and Mtwo) were more efficient than NiTi- hand files, but this was, in some cases, at the expense of remaining dentine-wall thickness

Paque et al(2009)[45] evaluated preparation of oval-shaped root canals in mandibular molars using nickel-titanium Rotary Instruments and analysed it with a micro-computed tomography study, Before and after shaping, teeth were evaluated using MCT at 34-mm resolution. The percentage of prepared surface was assessed for the full canal length and the apical 4 mm preparations of ovalshapedroot canals in mandibular molars left a variable portion of surface area unprepared regardless of the instrumentation technique used. Thus, considering oval canals as two separate entities during preparation appeared to be beneficial in increasing overall prepared surface.

Taha et al (2010)[53] compared three techniques for preparing oval-shaped root canals: Anatomic Endodontic Technology (AET), hand instruments; and rotary nickel-titanium instruments with regard to cleaning ability and final canal shape. Three groups each of 13 extracted human mandibular premolars with oval-shaped canals were used. After canal preparation, teeth were sectioned at three levels (coronal, middle, and apical),photographed to assess cross-sectional canal shape, and processed for histologic evaluation of canal wall planning and the presence of debris .finally they concluded that AET did not perform better than rotary NiTi or hand instruments in oval-shaped canals.

Z. Metzger et al (2010 April)[37] evaluated the cleaning ability of the Self-Adjusting File (SAF) system in terms of removal of debris and smear layer using scanning electron microscope. Root canal preparations were performed in 20 root canals using an SAF operated with a continuous irrigation device. The glide path was initially established using a size 20 K-file followed by the SAF file that was operated in the root canal via a vibrating motion for a total of 4 minutes. Sodium hypochlorite (3%) and EDTA (17%) were used as continuous irrigants and were alternated every minute during this initial 4-minute period. This was followed by a 30-second rinse using EDTA applied through a non-activated SAF and a final flush with sodium hypochlorite. The roots were split longitudinally and subjected to scanning electron microscopy (SEM). The SAF operation with continuous irrigation,

using alternating irrigants, resulted in root canal walls that were free of debris in all thirds of the canal in all (100%) of the samples. They concluded that the operation of the SAF system with continuous irrigation coupled with alternating sodium hypochlorite and EDTA treatment resulted in a clean and mostly smear layer-free dentinal surface in all parts of the root canal.

Z. Metzger et al (2010 April)[38] discussed about a new concept, the self-adjusting file (SAF), and discuss its unique features compared with current rotary nickel-titanium file systems. The SAF file is hollow and designed as a thin cylindrical nickel-titanium lattice that adapts to the cross-section of the root canal. A single file is used throughout the procedure. It is inserted into a path initially prepared by a # 20 K-file and operated with a trans-line (in-and-out) vibration. The resulting circumferential pressure allows the file's abrasive surface to gradually remove a thin uniform hard-tissue layer from the entire root canal surface, resulting in a canal with a similar cross-section but of larger dimensions. This holds also for canals with an oval or flat cross-section, which will be enlarged to a flat or oval cross-section of larger dimensions. The straightening of curved canals is also reduced because of the high pliability of the file and the absence of a rigid metal core. Thus, the original shape of the root canal is respected both longitudinally and in cross-section. The hollow SAF file is operated with a constant flow of irrigant that enters the full length of the canal and that is activated by the vibration and is replaced continuously throughout the procedure. This results in effective

cleaning even at the cul de sac apical part of the canal. The SAF has high mechanical endurance; file separation does not occur; and mechanical failure, if it occurs, is limited to small tears in the latticework. Thereby they concluded that the SAF represents a new step forward in endodontic file development that may overcome many of the shortcomings of current rotary nickel-titanium file systems.

R. Hof et al (2010 April)[29] evaluated the mechanical properties of the self-adjusting file (SAF) and its application in the root canal using continuous irrigation. The SAF file was elastically compressible from a diameter of 1.5 mm to dimensions similar to those of a #20 stainless steel K-file. This compression resulted in an evenly applied force to the root canal walls. The in-and-out vibration of the file and the peripheral force, combined with its abrasivity, allow for hard-tissue removal. Under the conditions of the experiment, no mechanical failure was observed with up to 29 minutes of operation in the root canal. The file loses its efficacy after prolonged use, with a 40% reduction after 30 minutes of operation. Therefore it was concluded that the SAF file is an elastically compressible file that effectively removes dentin and can mechanically endure use under its recommended mode of operation with a minimal loss of efficacy.

A. peters et al (july2010)[40] studied the dentin removal ability of a novel nickel-titanium instrument, the self-adjusting file (SAF), by using micro-computed tomography. They concluded that the Preparation of straight root canals in maxillary anterior teeth left little canal surface un-instrumented after shaping with the SAF. The timeframe of clinical application will depend on the amount of desired dentin removal and done with an SAF selected on the basis of apical gauging.

Zvi Metzger et al (2010 september)[39] evaluated the quality of root canal preparation and root canal obturation in canals treated with either rotary or self adjusting files, using three-dimensional micro–computed tomographic (CT) analysis. Within the limitations of the present study, the self-adjusting files allowed better cleaning and shaping and better adaptation of the root canal filling than those allowed by rotary files.

J. F. Siqueira et al (2010 November)[51] compared the capability of a newly developed instrument, the self-adjusting file (SAF), and rotary nickel-titanium (NiTi) instrumentation to eliminate Enterococcus faecalis populations from long oval root canals of extracted human teeth. Long oval canals from mandibular incisors and maxillary second premolars were infected with E.faecalis for 30 days and then randomly distributed into 2 experimental groups. In group 1, canals were prepared up to a 40/04 rotary BioRaCe instrument by using irrigation with NaviTip needles; in group 2, canals were prepared by using the SAF system with continuous irrigation. NaOCl and

ethylenediaminetetraacetic acid were used as irrigants. Bacteriologic samples were taken before (S1) and after preparation.Finally, they concluded that the SAF system was significantly more effective than rotary NiTi instrumentation used with syringe/needle irrigation in disinfecting long oval root canals in vitro. A modified sampling technique might be necessary for oval canals.

M Chokkalingam et al (jan2011)[11]evaluated the adequacy of three obturation techniques namely lateral condensation, EQ Fil (backfill obturation) and thermafil (core carrier obturation) techniques using three-dimensional (3D) helical computed tomography (CT) by volume rendering method . Thirty freshly extracted teeth were randomly divided into three groups of 10 teeth each. Biomechanical preparation was done in all the teeth using rotary instruments. All three sets of teeth were placed in helical CT slice scanner and were imaged before obturation. The three sets were then obturated by following methods: Group I: lateral condensation, Group II: EQ Fil (backfill) and Group III: thermafil (core carrier obturation).Volume of the pulp chamber and gutta-percha after obturation were calculated using volume rendering technique and adequacy of the obturation techniques were calculated. Conventional lateral condensation technique showed maximal inadequacy of obturation and thermafilobturation technique showed the least inadequacy of obturation when the volume of the specimens were calculated and reconstructed

S. Yigiit-ozer et al (2011 February)[64] analysed the debridement capacity of a novel system, SAF and its special irrigation device when used with different operation times in curved root canals. 30 mesiobuccal root canals of maxillary molars were instrumented using SAF. Teeth were divided into three groups. In Group 1, 10 new SAF files were used for operation for 4 minutes. In Group 2, the 4-min previously used SAF files were operated in the same manner. In Group 3, the 8-min previously used SAF files were operated. During SAF operation 2.6 % NaOCl and 17 % EDTA were used alternately in all groups. Debris and smear layer removal were evaluated for the apical thirds under scanning electron microscope. They concluded that When SAF is operated in curved root canals with continuous flow of irrigation it results in debris and smear-free canal walls in the critical apical thirds within 12 minutes.

Gustavo De-Deus et al(may2011)[16] compared the debridement quality of the Self-Adjusting File (SAF) system in oval canals and compare it with the debridement achieved by a commonly used NiTi rotary system.so finally he concluded The SAF protocol was significantly more efficient for debridement of oval root canals than the rotary ProTaper protocol.

Ö. Adigüzel, et al (2011 December)[1] examined the cleaning ability of a self-adjusting file (SAF) system regarding debris and smear layer removal using ethylenediaminetetraacetic acid (EDTA) or MTAD. In total, 45 maxillary incisor teeth were randomly divided into 2 different irrigation

groups of 20 canals each and a negative control group of 5 canals. The presence of debris and smear layer in the coronal, middle, and apical thirds of the canal was evaluated using a 5-grade scoring system with X200 and X2,000 magnification, respectively. The SAF operation with 2-minute continuous irrigation using MTAD resulted in root canal walls that were free of smear layer in 85%, 70%, and 60% and of debris in 95%, 90%, and 95% of the coronal, middle, and apical thirds of the root canals, respectively. The SAF operation with continuous irrigation using EDTA resulted in root canal walls that were free of smear layer in 85%, 60%, and 50% and of debris in 95%, 90%, and 85% of the coronal, middle, and apical thirds of the root canals, respectively.They concluded that When using the SAF, the protocols used in this study were effective for debridement for all regions of the root canal even for the apical thirds.

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A. Paranjpe et al (2012 February)[47] compared the ability of SAF with the ProTaper rotary file system in debris and smear layer removal and disinfection by using microbiological and scanning electron microscopy (SEM) evaluation. Fifty maxillary premolars were inoculated with Enterococcus faecalis for 30 days and then randomly distributed into 2 groups. Group 1 was prepared with ProTaper rotary instruments and irrigated with 30-gauge side-vented needles. Group 2 was prepared by using the SAF system with continuous irrigation. Bacteriologic samples were taken before and after

preparation.They finally concluded that the SAF system does not allow control of the apical enlargement, thus limiting the ability of the irrigants to achieve effective and predictable disinfection.

O. Yoldas et al (2012 February) [66] compared dentinal microcrack formation while using hand files (HFs), 4 brands of nickel-titanium (NiTi) rotary files and the self-adjusting file. One hundred forty mandibular first molars were selected: 20 teeth were left unprepared and served as control, and the remaining 120 teeth were divided into 6 groups. Roots were then sectioned 3, 6, and 9 mm from the apex, and the cut surface was observed under a microscope and checked for the presence of dentinal microcracks.The study concluded that all rotary files created microcracks in the root dentin, whereas the SAF file and hand instrumentation presented with satisfactory results with no dentinal microcracks.

F. Paqué et al (2012 May)[45] evaluated the accumulation of hard-tissue debris when using the Self-adjusting File (SAF) system in mesial roots of mandibular molars with isthmuses and to compare it with that occurring when the ProTaper file system was used. Forty extracted human mandibular molars with joining mesial root canals and an isthmus between the two canals were randomly assigned to two experimental groups and scanned using micro-computed tomography . After final scanning, the per cent value of total canal system volume filled with hard tissue debris was calculated After final scanning, the per cent value of total canal system volume filled with hard

tissue debris was calculated, Instrumentation of the root canals with ProTaper left 10.1% (IQR 5.2) of the total canal system volume filled with hard-tissue debris while preparation with the SAF left 1.7% (IQR 1.6). This difference was highly significant .they concluded that the Preparation with the SAF system resulted in less hard-tissue debris accumulation in isthmus-containing root canal systems compared with instrumentation with ProTaper rotary files.

A.De-Deus et al(2012 June)[14] compared the filling ability of carrier-based thermoplasticized gutta-percha in flat-oval canals prepared using either rotary ProTaper files (DentsplyMaillefer, Ballaigues, Switzerland) or the Self-Adjusting File system (SAF), Teeth from each pair were randomly assigned to 1 of 2 experimental groups. One group was instrumented using the ProTaper NiTi system, whereas the SAF system was used in the other. Root filling was performed with Thermafilobturators (Dentsply Tulsa Dental Products, Tulsa, OK), and teeth were sectioned at 6, 5, 4, and 3mmfrom the apex; the cut surface was subjected to morphometric measurement to establish the percent gutta-percha–filled area (PGFA) for each section.He concluded that the instrumentation of the flat-oval canals with the SAF system led to a significantly higher PGFA compared with ProTaper instrumentation with syringe and needle irrigatiON.

A. Dietrich et al (2012 August)[3] compared the effectiveness of debris removal between the Self-Adjusting File (SAF), WaveOne, and K3 file systems in the mesial roots of mandibular molars. In addition, the SAF was

tested as a potential adjunct after instrumentation with other systems. The mesial roots of 30 extracted mandibular molars were mounted in resin by using the K-Kube, sectioned at 2 and 4 mm from working length, and randomly placed into 3 groups: K3 group, sequential preparation with K3 files to an apical size of 35/.04; WaveOne group, preparation with WaveOne primary file; and SAF group, preparation with SAF. Images were taken before instrumentation, after instrumentation, after final irrigation, and after SAF adjunct irrigation. A cleanliness percentage was calculated by using interactive software. Comparisons between groups were analyzed with repeated-measures analysis of variance and post hoc tests .Finally, they concluded that There was no differences in canal cleanliness between the 3 file systems; however, the SAF and K3 files performed significantly better than the WaveOne with respect to isthmus cleanliness. When used as a final irrigation adjunct device after instrumentation, the SAF provided a significant improvement only in a subset of the K3 group.

A. De-Deus et al (2013 February)[13] assessed the bond strength of root fillings in oval-shaped canals prepared with the self-adjusting file (SAF) system. A careful specimen selection resulted in 2 equal groups, One group was subjected to the SAF protocol, and the other group underwent conventional protocol, which was the ProTaper system with syringe-needle irrigation, The teeth were obturated in a standardized way, filled with a Lentulo spiral as the root filling, and then prepared for micropush-out

assessment by using root slices of 1-mm thickness. All specimens showed measurable adhesive properties to root dentin. In addition, no premature failure occurred.Finally,it was concluded that the SAF preparation markedly influenced root-filling push-out bond strength in oval-shaped canals. Further investigations are needed to provide a better understanding of the physicochemical modifications of the root dentin prepared with the SAF cleaning-shaping-irrigation system.

E. S. Hin et al (2013 February)[28] studied the incidence of cracks in root dentin after root canal preparation with hand files, self-adjusting file (SAF), ProTaper, and Mtwo. Five groups of 20 teeth each were comparable in canal width. The control group was left unprepared. Four experimental groups were instrumented with hand files, ProTaper, Mtwo, and SAF. Roots were then sectioned horizontally and observed under a microscope. The presence of dentinal cracks and their location were noted. In the experimental groups, ProTaper, Mtwo, and SAF caused cracks in 35%, 25%, and 10% of teeth, respectively. The hand-file group did not show any dentinal cracks. ProTaper and Mtwo caused more cracks than hand files, but SAF did not. The study concluded that Instrumentation of root canals with SAF, Mtwo, and ProTaper could cause damage to root canal dentin. SAF has a tendency to cause less dentinal cracks as compared with ProTaper or Mtwo.

M. V. de MeloRibeiro et al (2013 March)[36] evaluated the tissue debridement efficacy of the self-adjusting file (SAF) protocol in the apical

third of oval-shaped canals of mandibular incisors in comparison with a nickel titanium rotary system preparation, 2 experimental groups (n = 11) according to 1 of 2 instrumentation techniques, SAF and nickel-titanium rotary systems. After root canal preparation, the apical thirds of the specimens were submitted to histologic processing and analyzed by optical microscopy regarding the percentage of debris and un-instrumented root canal walls.They concluded that the SAF had significantly more contact to the dentin walls and removed more debris than rotary instrumentation in the apical third of mandibular incisors.

Dilek Helvacioglu Yigit et al (June 2013)[17] evaluated the apical seal obtained with lateral compaction of gutta-percha in oval-shaped root canals prepared with either self-adjusting files or ProTaper Universal rotary files. Twelve pairs of extracted mandibular premolars with oval-shaped root canals were randomly divided into two groups. The first group was biomechanically prepared with ProTaper Universal files, while the self-adjusting file system was used in the second group. The roots were filled using cold lateral compaction of gutta-percha. Apical microleakage was measured with the computerized fluid filtration method. The results were analyzed statistically using the Mann-Whitney U test. They concluded that Instrumentation of oval-shaped canals using a self-adjusting file system with cold lateral compaction of gutta-percha demonstrated significantly greater apical microleakage when compared to ProTaper Universal. The apical leakage with different filling

techniques, combined with self-adjusting files, should be evaluated in further studies.

M. A. S. Neves et al (june2013) [42] evaluated in vivo, the antibacterial effectiveness of the self-adjusting file (SAF) using molecular methods, under his examination the SAF instrumentation system was highly effective in reducing bacterial populations from infected root canals and performed significantly better than hand instrumentation. However, because half of the samples still had detectable bacteria after preparation with SAF, supplementary disinfection is still required to maximize bacterial elimination.

S. Koçak et al (2013 October)[34] assessed the weight of debris extruded apically from teeth using different in vitro preparation techniques. Sixty-eight extracted human mandibular premolars with single canals and similar lengths were instrumented using ProTaper F2 (25, .08; DentsplyMaillefer, Ballaigues, Switzerland), the Self-Adjusting File (1.5-mm diameter; Re-Dent Nova, Ra'anana, Israel), Revo-S SU (25, .06; MicroMega, Besancon, France), or Reciproc (R25; VDW GmbH, Munich Germany). Debris extruded during instrumentation were collected into preweighed Eppendorf tubes. There were no statistically significant differences among the groups (P = .218). The ProTaper group produced the highest mean extrusion value. The Reciproc produced less debris compared with all the other instruments

Ellemieke s et al (2013) [20]observed the incidence of cracks in root dentin after root canal preparation with hand files, self-adjusting file (SAF), ProTaper, and Mtwo. Four experimental groups were instrumented with hand files, ProTaper, Mtwo, and SAF. Roots were then sectioned horizontally and observed under a microscope. The presence of dentinal cracks and their location were noted,Instrumentation of root canals with SAF, Mtwo, and ProTaper could cause damage to root canal dentin. SAF has a tendency to cause less dentinal cracks as compared with ProTaper or Mtwo.

Jim E. Ruckman et al(2013)[48] compared the root canal debridement ability of the self-adjusting file (SAF) with ProFile rotary (PF) and hand filing (HF) instrumentation. Extracted human teeth (n = 30) were selected on the basis of a root canal ratio of 2.5:1 measured 5 mm from the root apex. Canals were filled with a radiopaque contrast medium (Vitapex) and instrumented by using SAF, PF, or HF with 20 mL of saline irrigation. Teeth receiving irrigation alone served as controls. Preoperative and postoperative radiographs were taken and submitted to digital subtraction, and the percentage reduction of contrast medium was quantified at 0–5 mm and >5–10 mm from the apex. All 3 techniques removed contrast medium equally well from the 0-to 5-mm segment of longoval– shaped canals. The SAF performed significantly better than hand filing in the >5-to 10-mm canal segment

James Lin et al (2013)[33] compared the efficacy of hand, rotary nickel-titanium, and self-adjusting file (SAF) instrumentation in biofilm bacteria removal, The scanning electron microscope showed a consistently thick layer of biofilm grown in the canals of the control group after 4 weeks. Within the groove, a smaller area remained occupied by bacteria after the use of the SAF compared with the ProFile and the K-file,the results were shown thatFor all groups, significantly more bacteria were removed outside the groove than insideAlthough all techniques equally removed bacteria outside the groove,the SAF reduced significantly more bacteria within the apical groove. No technique was able to remove all bacteria. This biofilm model represents a potentially useful tool for the future study of root canal disinfection.

I. D. Çapar et al (2014 April)[8] evaluated the fracture strength of roots instrumented with the Self-Adjusting File (SAF; ReDent-Nova, Ra'anana, Israel) and the ProTaper system (DentsplyMaillefer, Ballaigues, Switzerland) and filled with the cold lateral compaction technique. They were distributed into 4 experimental groups and 1 control group (n = 10): no instrumentation (control group), instrumentation with ProTaper rotary files but no filling (PT), instrumentation with ProTaper rotary files and filling with cold lateral compaction (PT filling), instrumentation with SAF but no filling (SAF), and instrumentation with SAF and filling with cold lateral compaction (SAF filling). AH Plus sealer (DentsplyDeTrey, Konstanz, Germany) was used along with gutta-percha points. One week later, a vertical load was applied to

the specimen's canal until fracture occurred. It was concluded that the instrumentation with the SAF or the ProTaper rotary system did not change the fracture strength of standardized roots with respect to cross-sectional diameter and weight.

Versiani et al (July 2014)[54] evaluated root canal preparation in flat-oval canals treated with ProTaper, Reciproc or self-adjusting file (SAF) instruments. The areas of prepared canal walls were significantly higher with the SAF than the ProTaper or Reciproc instruments. The SAF removed the dentin layer from all around the canal, whereas the others left substantial untouched areas.So finally In the coronal third, mean increases in the area of the canal were significantly higher with the SAF than with ProTaper or Reciproc. Using the SAF instrument, flat-oval canals were prepared homogenously and circumferentially 8.F. Paquéet al(april2011) Evaluated the Preparation of Long Oval Root Canals in Mandibular Molars with the Self-Adjusting File. The aim of this study was to assess the shaping potential of a novel nickel-titanium instrument, the self-adjusting file (SAF), in long oval root canalswhich are present in distal roots in mandibular molars. Canals were shaped with the SAF, three-dimensionally reconstructed, and evaluated for volume, surface area, canal transportation, and prepared surface. Unprepared canal surface varied between individual canals, and mean unprepared surface, Prepared areas were significantly larger compared with rotary canal preparation done in a previous study. so finally they concluded that

preparation of long oval-shaped root canals in mandibular molars with the SAF was effective and safe. Moreover, shapes generated with the SAF were more complete compared with rotary canal preparation

E. Uzunoglu et al (2014 July)[53] studied the amount of apically extruded debris by the Self-Adjusting-File system (SAF; ReDent-Nova, Ra'anana, Israel). Hand and rotary instruments were used as references for comparison. The aim of this in vitro study was to assess the amount of apically extruded debris and irrigant using Reciprocvs self-adjusting file (SAF) and to investigate the effect, if any, of gravitational force via mandibular and maxillary positioning of the teeth. All instrumentation techniques and positions caused measurable apical extrusion of debris. A significant difference was observed according to position and instrument used ($p < 0.05$). The Reciproc extruded significantly more debris than SAF and vial downward position extruded significantly more debris than upward position

K. M. Topcu et al (2014 July) compared the canal debridement capabilities of three single file systems, ProTaper, and K-files in oval-shaped canals, Seventy-five extracted human mandibular central incisors with oval-shaped root canals were selected. A radiopaque contrast medium (Metapex; Meta Biomed Co. Ltd., Chungcheongbuk-do, Korea) was introduced into the canal systems and the self-adjusting file (SAF), WaveOne, Reciproc, ProTaper, and K-files were used for the instrumentation of the canals. The percentage of removed contrast medium was calculated using pre- and post-

operative radiograph. overall comparison between the groups revealed that the hand file (HF) and SAF groups presented the lowest percentage of removed contrast medium, whereas the WaveOne group showed the highest percentage, The ProTaper group removed more contrast medium than the SAF and HF groups

D. Ozsu,et al (2014 oct)[43] compared the amount of apically extruded debris during preparation with ProTaper Universal (DentsplyMaillefer, Ballaigues, Switzerland), ProTaper Next (DentsplyMaillefer), a reciprocating single-file (WaveOne; VDW GmbH, Munich, Germany), and a self-adjusting file. Fifty-six intact mandibular premolar teeth were randomly assigned to four groups. The root canals were prepared according to the manufacturers' instructions using the ProTaper Universal, ProTaper Next, WaveOne, and SAF. Apically extruded debris was collected in preweighted Eppendorf tubes during instrumentation. The net weight of the apically extruded debris was determined by subtracting the preweights and postweights of the tubes, A measurable amount of debris was apically extruded in all groups, and they concluded that the SAF group resulted in the least debris extrusion

Copar et al (2014 November)[8], Effectiveness of Various Irrigation Activation Protocols and the Self-Adjusting File System on Smear Layer and Debris Removal was studied. The purpose of the present study is to evaluate smear layer generation and residual debris after using self-adjusting file (SAF) or rotary instrumentation and to compare the debris and smear layer removal

efficacy of the SAF cleaning/shaping irrigation system against final agitation techniques. One hundred and eight maxillary lateral incisor teeth were randomly divided into nine experimental groups (n = 12), and root canals were prepared using ProTaper Universal rotary files, with the exception of the SAF instrumentation group. During instrumentation, root canals were irrigated with a total of 16 mL of 5% NaOCl. For final irrigation, rotary-instrumented groups were irrigated with 10 mL of 17% EDTA and 10 mL of 5% NaOCl using different irrigation agitation regimens. In the SAF instrumentation group, root canals were instrumented for 4 min at a rate of 4 mL/min with 5% NaOCl and received a final flush with same as syringe irrigation with needles. The surface of the root dentin was observed using a scanning electron microscope.The SAF instrumentation group generated less smear layer and yielded cleaner canals compared to rotary instrumentation. The EndoActivator, EndoVac, PUI, and SAF irrigation groups increased the efficacy of irrigating solutions on the smear layer and debris removal. The SAF instrumentation yielded cleaner canal walls when compared to rotary instrumentation. None of the techniques completely removed the smear layer from the root canal walls.

Hammad et al (2015 February)[26] evaluated the amount of apically extruded debris in flat-oval root canal systems during cleaning and shaping with different instrumentation systems. Seventy-two mandibular incisors were randomly assigned to 4 groups (n = 18) according to the instrumentation system to be used: the ProTaper Next rotary system (PTN; Dentsply Tulsa

Dental, Tulsa, OK), the WaveOne reciprocating system (WO, Dentsply Tulsa Dental), the Twisted File Adaptive (TFA; SybronEndo, Orange, CA) rotary/reciprocating system, and the Self-Adjusting File (SAF) system (ReDent-Nova, Ra'anana, Israel). Debris extruded during the instrumentation was collected and dried in preweighed Eppendorf tubes.

Three consecutive weights were obtained for each tube, and the average was calculated. The data were analyzed using the t test and analysis of variance (Games-Howell test). Regardless of the instrumentation system used, apical extrusion of debris was exhibited at some level, regardless of the instrumentation system used. They concluded that The SAF was associated with the highest amount of debris extrusion compared with PTN, WO, and TFA.

A. M. Pawar et al in (2015March)[46] evaluated the debris extrusion after instrumenting the root canals by three different files systems Sixty extracted human mandibular premolars with single canals were selected and randomly divided into three groups for instrumentation with three different files. Group 1: WaveOne single reciprocating file Group 2: Self-adjusting file, and Group 3: ProTaper NEXT X1 and X2, Statistical analysis for the debris extruded apically was performed using one-way analysis of variance and post hoc Tukey's test. Finally, they concluded that The SAF resulted in

significantly less extrusion of debris when compared to reciprocating WO and rotary PTN.

F. Ahmetoglu et al (may2015)[2] compared the root canal preparations of maxillary first molars with self-adjusting file, reciproc Single File, and Revo-S Rotary File and finally evaluated with (μ-CT), in maxillary first molars.The root canals were shaped with SAF, Reciproc, and Revo-S, respectively. The shaped root canals were rescanned. Changes in canal volumes and surface areas were compared with preoperative values. The data were analyzed, Surface area showed the similar activity in buccal canals in each of the three techniques whereas no statistically significant difference was detected among surface area, the SAF, and the Revo-S in the palatal (P) canal. Each of three shaping system showed the similar volume activity in all canals, but SAF and Revo-S provided more effectively root planning in comparison with Reciproc in P canal.

Z Mohammadi1 et al (June 2015)[40]stated that oval shaped root canals. These canals created great challenges during the instrumentation and obturation phases of root canal treatment. Files used circumferentially in a reciprocating hand-piece improved the preparation of the oval coronal-middle part of the root canal. Non-square cross-sectional designed instruments are generally more efficient during cleaning and shaping than a square cross-sectional designed instrument. For obturation of these canals, thermoplastic

techniques were used which may be equivalent to or better than the lateral condensation technique and this thermoplastic technique was less dependent on the canal shape than lateral condensation.

Materials and Methods

ARMAMENTARIUM

- Extracted mandibular incisor
- K-files (10# to 25# MANI,INC)
- Finger spreaders(15# to 40# MANI,INC)
- Hand plugger (Dispodent)
- 3% Sodium hypochlorite for irrigation & cleaning
- 17% EDTA(RC Help Prime dental products pvt Ltd)
- Straight micro motor hand piece (NSK)
- Diamond disc and lab micro-motor
- 2% gutta-percha (DENTSPLY)
- Paper points (DENTSPLY)
- Conventional zinc oxide powder (DEEPAK ENTERPRISES)
- Eugenol liquid (DEEPAK ENTERPRISES)
- Gutta-percha pellets and catridge (sybron endo)
- Wave-One file system (DENSPLY)
- SAF system.(ReDent-Nova, Raanana, Israel)
- X smart plus (densply Tulsa dental, maillefer)
- Element obturation unit (Sybron endo)
- Computed tomography(Manufacturer -*REVOLUTION ACTs)

Sample collection:

- 60 extracted human mandibular incisors were collected from the department of Oral &Maxillofacial Surgery, Ragas Dental college and Hospital, Chennai.

Inclusion criteria:

- Tooth with mature apices
- Single canal

Exclusion criteria :

- Tooth with root caries
- Tooth with cracks and fractures
- Tooth with calcified canals

Experimental Design

The study was designed to compare two instrumentation methods using three-dimensional parameters:

(1) The quality of root canal cleaning and shaping, as expressed by the root canal wall area affected/unaffected by the procedure, and

(2) The quality of obturation, as expressed by the percent of the root canal wall area (after preparation) touched/untouched by the root canal filling material.

Teeth Selection

Teeth were selected from a large random collection of extracted human teeth that were recently extracted for reasons unrelated to the present study and kept in 10% buffered formalin, 60 teeth were selected based on root canal morphology and immersed in 3%sodium hypochlorite and their external surfaces were carefully cleaned of calculus and debris with the help of ultrasonic scaler and washed under running water. Teeth were decoronated, and roots were standardized using a diamond disk operated at low speed to 15 mm in length .ISO size # 10 k file was inserted into root canal until just visible at apical foramen . Working length of each root canal was then established 1 mm short of the apical foramen. Each apex was sealed using sticky wax to stimulate the clinical situation.

Three dimensional cross-Sectional images were obtained using CT scanning (IPL software1.01)(data of field of view 1.30 cm,Kv-120,mA-50,slice thickness 0.6mm to 1.1mm) Teeth were decoronated horizontally below the cemento-enamel junction using a diamond disc to uniform lengths of 15mm.All the procedures were performed by a single operator.

The 60 samples were divided in to 2 experimental Groups, Group A (SAF) (n=30)and Group B (Wave-One) (n=30) respectively. Each Group further divided in to 2 subgroups based on obturation techniques namely cold lateral compaction and thermoplastized obturation technique.

PREPARATION OF THE SAMPLES:

GROUP A: PREPARATION WITH SELF ADJUSTING FILE SYSTEM (SAF) (30samples)

SAF(ReDent) was operated for 4 minutes using a Gentle-PowerLux 20LP KaVohandpiece, (KaVo, Biberach, Germany) adapted with a RDT3 hea**d (ReDent-Nova, Raanana, Israel)**. The micromotar rotation speed was set at 5000 rpm, which resulted in and out operation of 5000 vibration per minute with amplitude of 0.4mm. the file was used with manual in and out motion to the working length. Continuous irrigation was applied throughout the procedure at 5mL/min using a special irrigation apparatus (VATEA irrigation device , part of the SAF system ReDent). 3 % NaOCl used for irrigation during the first three minutes of operation followed by one min of irrigation with 17% EDTA. A final flush with 5 ml 3%NaOCl was used to remove EDTA, and the canal was dried using paper points.

GROUP B: PREPARATION WITH WAVEONE SYSTEM (30 samples)

WaveOne file large (ISO 040.08)was used to prepare the teeth with brushing and gentle inward stroking motion with short 2-3mm amplitude strokes. Irrigation was done with 2.5 ml of 3 % NaOCl and 17%EDTA.

CT images were obtained after the cleaning and shaping procedure of the root canals with SAF system and wave one system to evaluate the quality of root canal cleaning and shaping using SAF system and wave one system.

Further, these groups were subdivided in to two groups with 15 teeth respectively .In SAF group, 15 teeth were obturated with cold lateral compaction and 15 teeth were obturated with thermoplastized gutta-percha. The same method of obturation was followed in wave one system.

Cold lateral compaction

Each Group (n=15) root canal obturation was performed using the cold lateral compaction technique with gutta-percha and Zinc Oxide Eugenol sealer. A gutta-percha master cone was fitted with tug-back in each root canal.

Sealer was placed into the canal using a master cone followed by insertion of the master cone to the predetermined working length. Stainless steel finger spreaders were used to conduct the lateral compaction using accessory cones. When no additional cones could be inserted, the gutta-percha mass was cut off 1 mm apical to the canal using a heated hand plugger (Dispodent). The freshly cut surface was vertically condensed using a cold plugger (Dipodent). The sealer was then allowed to set for 4 days at 37°C and 100%humidity.

Thermoplastized obturation technique

Thermoplastized obturation was performed using Elements obturation unit, master cone was selected and fit 2mm short of the WL, after selecting appropriate master plugger is prefitted within 4 -6 mm of prepared length system B is set to 200 c in touch mode . sealer is coated into canal then master cone is placed 2mm short of working length plugger is inserted into canal and activated to remove the excess coronal material. Compaction is initiated by placing a cold plugger against the guttapercha with firm pressure and heat is activated, plugger is moved rapidly 1 to 2 seconds to within 3 mm of binding point, heat is inactivated while firm pressure is maintained in the plugger for 5 to 10 seconds. Remaining coronal portion of canal is backfilled by delivering thermoplastic guttapercha from a extruder at 100 c

The obturated teeth were then subjected to CT and then the images were super imposed with the images obtained with cleaning and shaping. And the data were analysed using newly developed software IPL (version 1.01), SVCT (version1.0)

The following statistical procedures were carried out:-

1. Data compilation and presentation

2. Statistical analyses

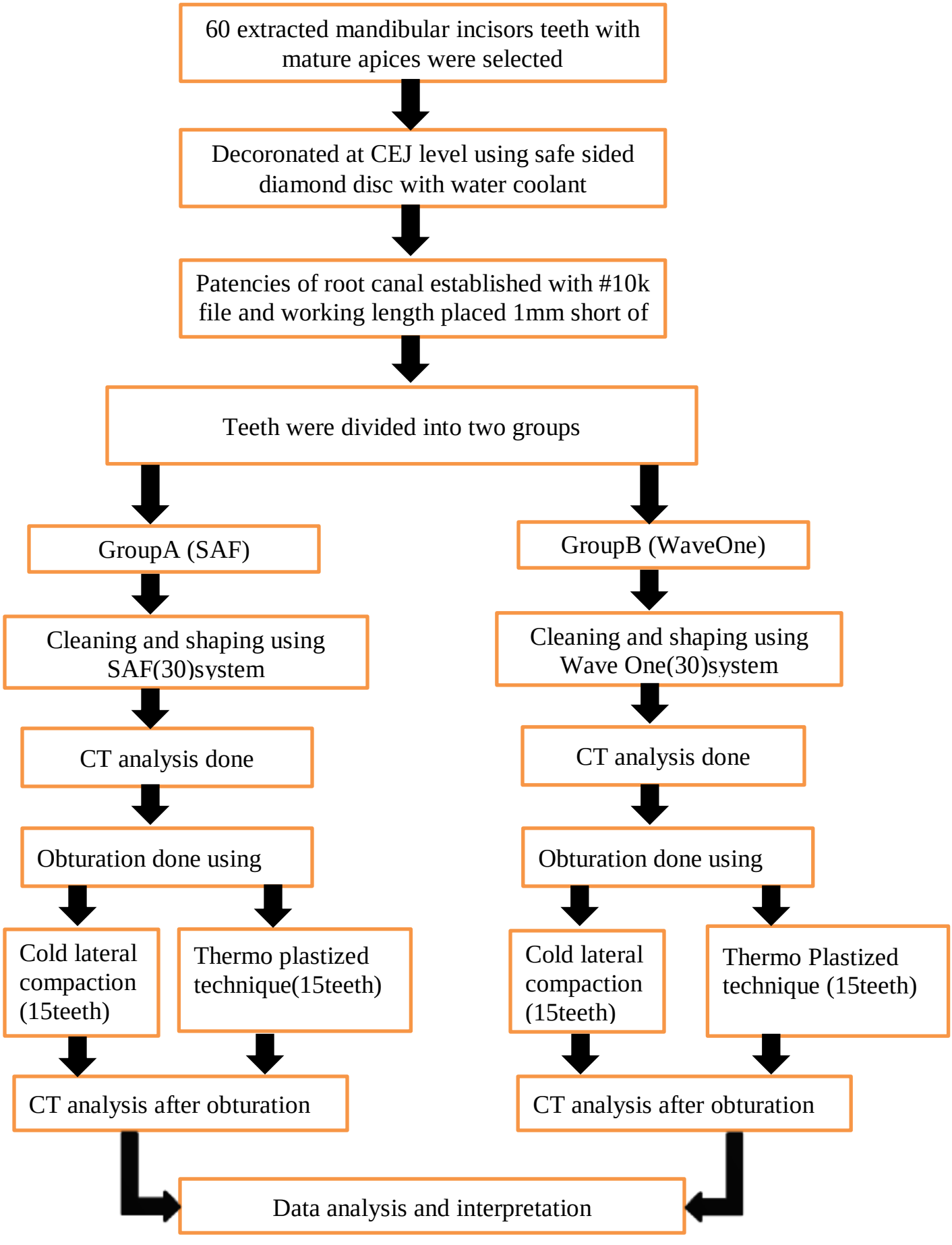
I. Data compilation and presentation:

Data obtained were compiled systematically in Microsoft Excel spreadsheet. The dataset was subdivided and distributed meaningfully and presented as graphs and tables.

II. Statistical analyses:

Statistical analyses were performed using Statistical Package for Social Sciences software (SPSS version 19, USA). Data comparison was done by applying specific statistical tests to find out the statistical significance of the obtained results. Depending upon the nature of the data, the statistical tests were chosen. p value of 0.05 was considered to be significant.

Normality was checked using Shapiro-Wilk test. All the data were found to be normal in distribution. Hence, parametric test was used. All comparisons were done using Student t test.


60 extracted mandibular incisors teeth with mature apices were selected
Decoronated at CEJ level using safe sided diamond disc with water coolant
Patencies of root canal established with #10k file and working length placed 1mm short of
Teeth were divided into two groups
GroupA (SAF)
GroupB (WaveOne)
Cleaning and shaping using SAF(30)system
Cleaning and shaping using Wave One(30)system
CT analysis done
CT analysis done
Obturation done using
Obturation done using
Cold lateral compaction (15teeth)
Thermo plastized technique(15teeth)
Cold lateral compaction (15teeth)
Thermo Plastized technique (15teeth)
CT analysis after obturation
CT analysis after obturation
Data analysis and interpretation

Figures

FIGURE 1. DECORONATED TOOTH-SAMPLES

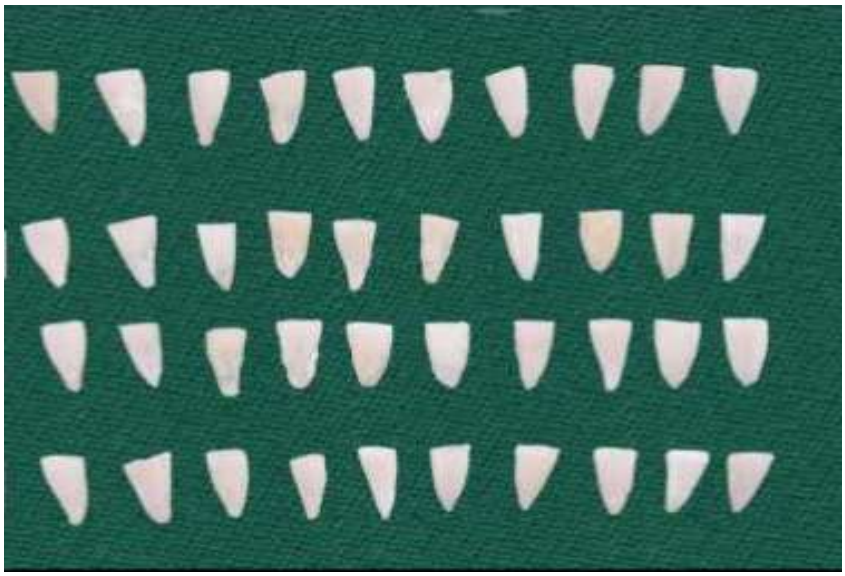


FIGURE 2. ARMAMENTARIUM

FIGURE 3. SELF ADJUSTING FILE

FIGURE 4. SAF SYSTEM

FIGURE 5. CANAL PATENCY ASSESSED USING #10 K FILE

FIGURE 6. INSTRUMENTATION WITH SELF ADJUSTING FILE

FIGURE 7. X-SMART PLUS (DENSPLY)

FIGURE 8. WAVE-ONE LARGE FILE

FIGURE 9. WAVE ONE INSTRUMENTATION

FIGURE 10. SEALER APPLICATION

FIGURE 11. OBTURATION OF SAMPLES USING COLD LATERAL COMPACTION TECHNIQUE

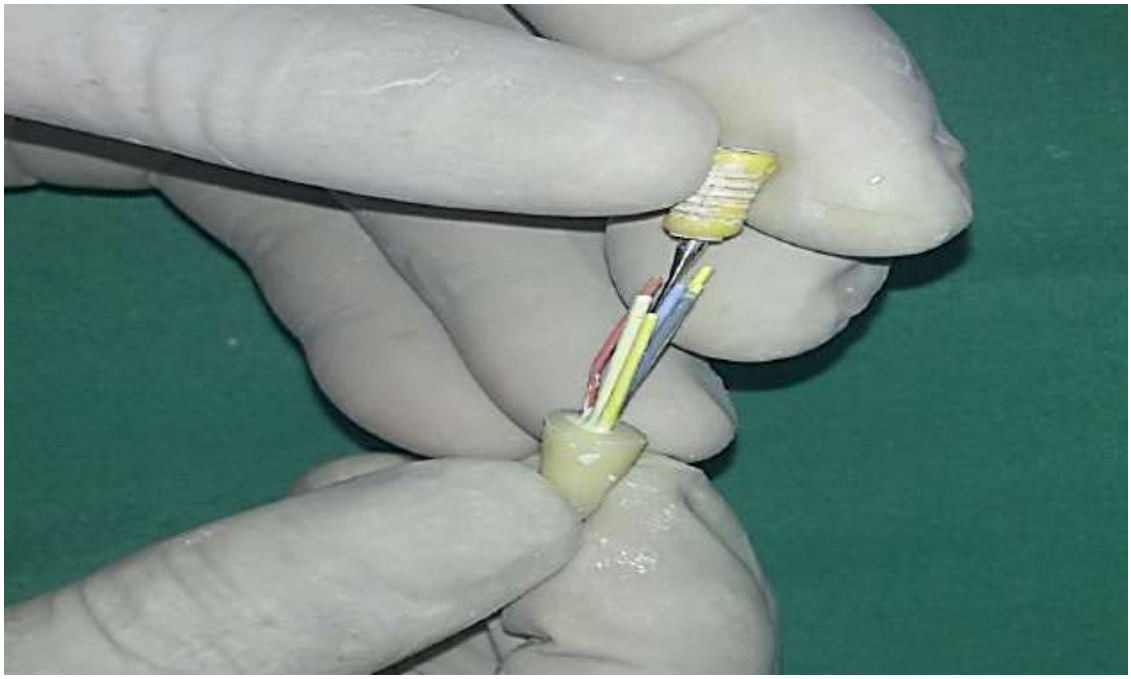


FIGURE 12. ELEMENT SYSTEM

FIGURE 13. ELEMENT GUTTA-PERCHA CATRIDGE

ELEMENT SYSTEM OBTURATION

FIGURE 14. CT SCAN

FIGURE 15. SAMPLE SCANNING

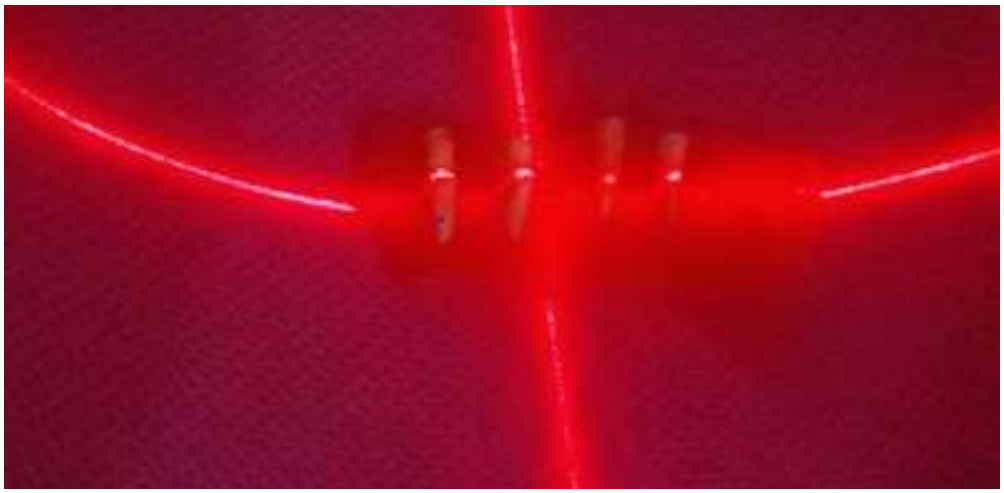


FIGURE 16. SUPER IMPOSED IMAGES SHOWING BEFORE AND AFTER INSTRUMENTATION IN OVAL SHAPED CANALS IN AXIAL VIEW

FIGURE 16a. SAF SYSTEM

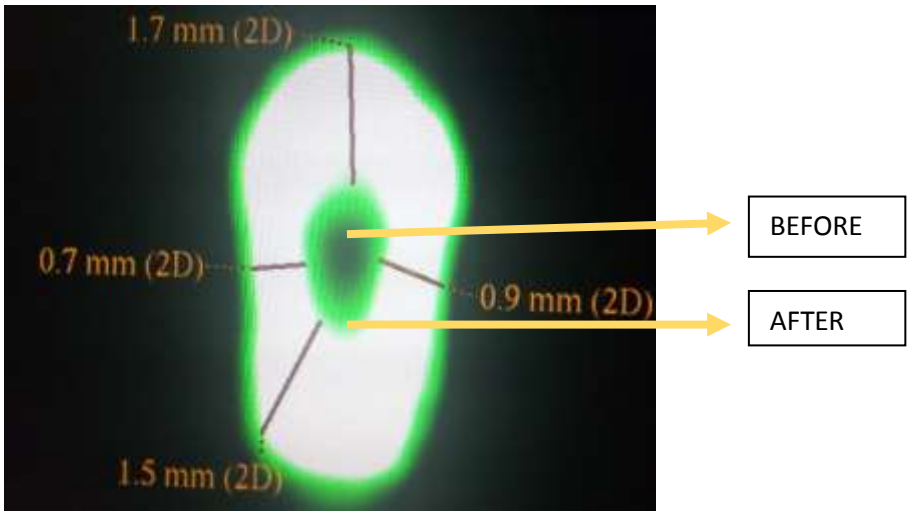


FIGURE 16b. WAVE ONE SYTEM

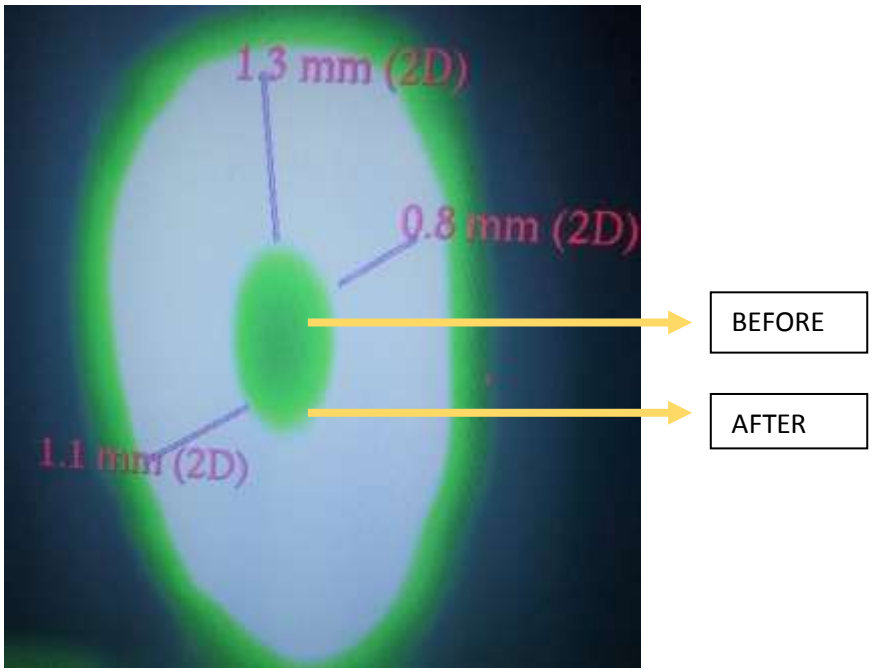
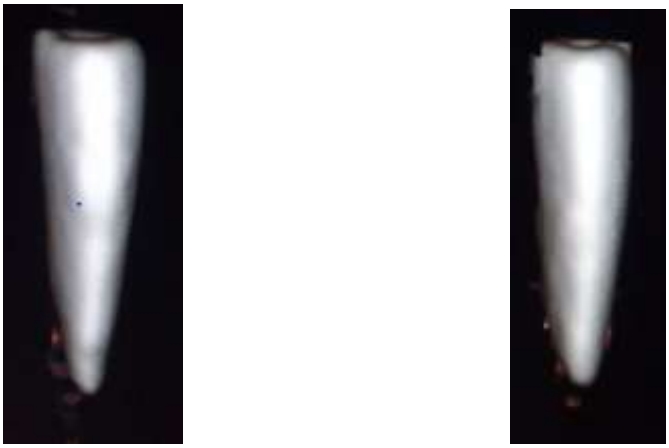


FIGURE 17: LONGITUDINAL VIEW OF OBTURATION IN COMPUTED TOMOGRAPHY

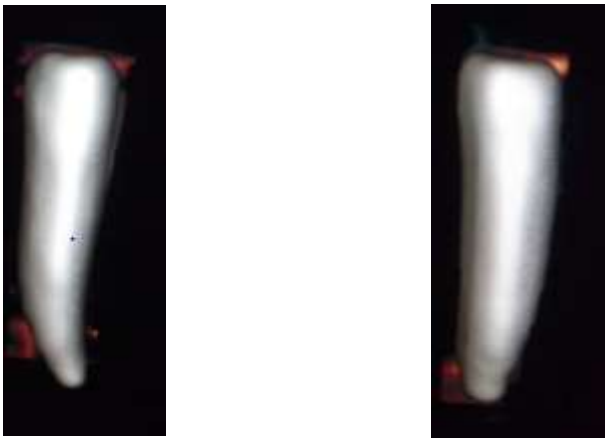


(A) **(B)**

SELF ADUSJTING FILE SYSTEM

(A)THERMOPLASTIZED OBTURATION

(B) COLD LATERAL COMPACTION



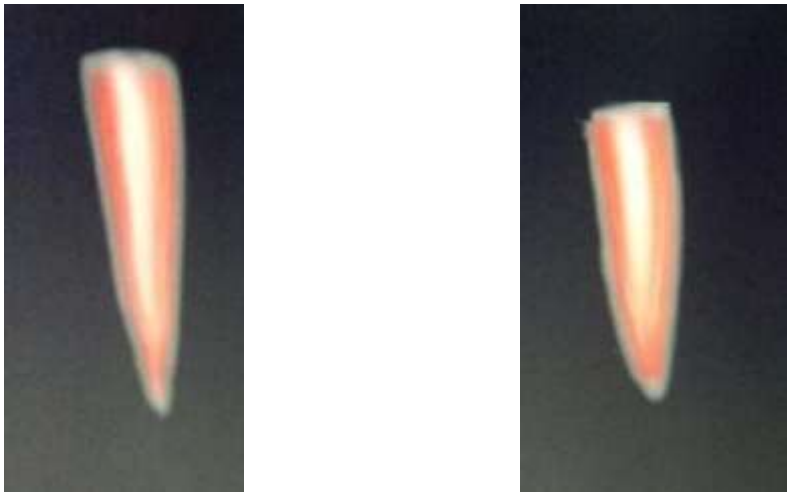
A **B**

WAVE ONE FILE SYSTEM

(A) THERMOPLASTIZED OBTURATION

(B) COLD LATERAL COMPACTION

FIGURE 18. SUPERIMPOSED IMAGES

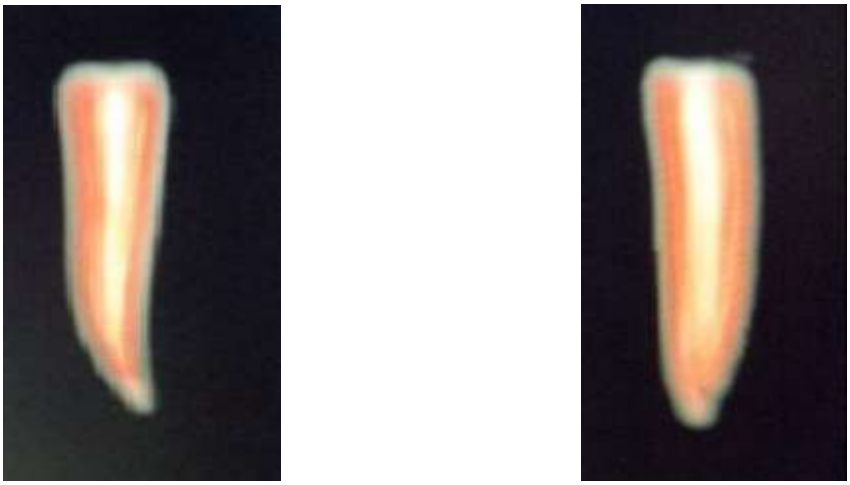


(A) **(B)**

SELF ADUSJTING FILE SYSTEM

(A) THERMOPLASTIZED OBTURATION

(B) COLD LATERAL COMPACTION



(A) **(B)**

WAVE ONE FILE SYSTEM

(A) THERMOPLASTIZED OBTURATION

(B) COLD LATERAL COMPACTION

Results

RESULTS

Data obtained were compiled systematically in Microsoft Excel spreadsheet. The dataset was subdivided and distributed meaningfully and presented as graphs and tables.

Statistical analyses were performed using Statistical Package for Social Sciences software (SPSS version 19, USA). Data comparison was done by applying specific statistical tests to find out the statistical significance of the obtained results. Depending upon the nature of the data, the statistical tests were chosen. P value of 0.05 was considered to be significant.

Normality was checked using Shapiro-Wilk test. All the data were found to be normal in distribution. Hence, parametric test was used. All comparisons were done using Student t test.

The present study aimed to evaluate the quality of obturationin oval shaped canals after using two rotary systems the SAF system and Wave One system with two different obturation technique,cold lateral compaction and thermoplastized guttapercha technique. The quality of the oburation for both the groups was assessed under Computer Tomography image.

The results of the study revealed that mean value of the obturation in the SAF group for thermoplastized obturation technique was 3.63±1.13 and in

the cold lateral compaction was 15.48±3.24.There was statistically significant difference among the thermoplastized obturation technique and cold lateral compaction technique in the SAF group with a p value of 0.001.

In the WAVEONE group for the thermoplastized technique mean value of the obturation was 23.24±2.00 and in the cold lateral compaction technique was 32.71±5.32. In the Wave One group there was statically significant difference among thermoplastized guttapercha technique and cold lateral compaction with p value of 0.001.

When the thermoplastized technique was compared among SAF system and Wave One system groups there was statistically significant difference with a p value of 0.001.

While the cold lateral compaction was compared in the SAF system and Wave One systems there was statistically significant difference among them with a p value of 0.001.

Tables and Graphs

Table 1: Three dimensional Computed Tomographic analysis of the quality of obturation of the oval shaped canals

S no	SAF –thermo (%)	SAF - lateral (%)	Waveone - thermo (%)	Waveone - lateral (%)
1	5.2	16.3	22.8	28.6
2	3.8	14.2	24.3	30.5
3	4.2	21.6	25.5	42.3
4	2.1	18.7	19.8	34.3
5	1.6	12.8	24.8	39.2
6	4.7	18.6	23.7	27.5
7	3.6	15.2	18.7	31.6
8	3.5	17.4	24.5	25.8
9	5.8	12.8	21.8	27.5
10	4.5	10.4	22.9	32.5
11	2.8	11.8	23.8	34.5
12	3.6	19.7	24.3	31.8
13	2.7	13.5	24.6	46.2
`14	2.8	12.8	21.6	34.7
15	3.6	16.4	25.5	27.3

Table 2: Comparison between thermoplastized technique and cold lateral compaction in the SAF system

Thermo (Mean±SD)	Lateral (Mean±SD)	p value
3.63±1.13	15.48±3.24	**0.001***

Unpaired t Test, *statistically significant

Table 3: Comparison between thermoplastized and cold lateral compaction in the WAVEONE system

Thermo (Mean±SD)	Lateral (Mean±SD)	p value
23.24±2.00	32.71±5.32	0.001

Unpaired t Test, *statistically significant

Table 4: Comparison between thermoplastized technique in SAF system and WAVEONE system:

SAF (Mean±SD)	WAVEONE (Mean±SD)	p value
3.63±1.13	23.24±2.00	0.001

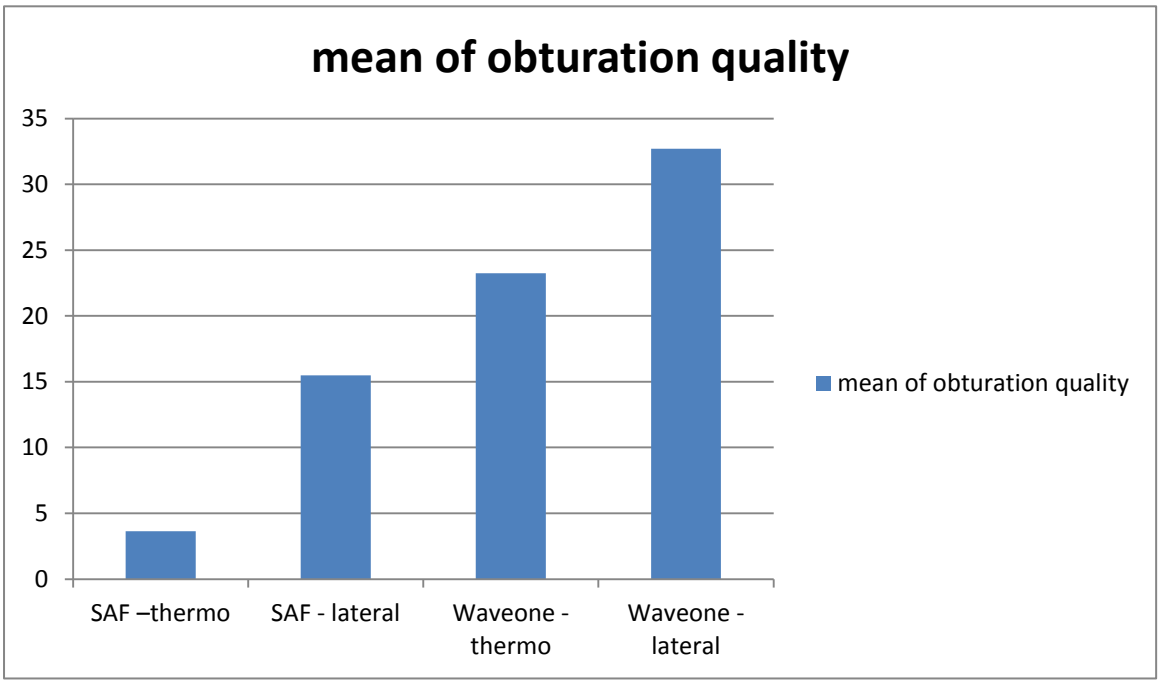
Unpaired t Test, * statistically significant

Table 5: Comparison between cold lateral compaction in SAF system and WAVEONE system:

SAF (Mean±SD)	WAVEONE (Mean±SD)	p value
15.48±3.24	32.95±5.85	**0.001**

Unpaired t Test, * statistically significant

Graph 1: Quality of obturation in SAF system and wave one system



Discussion

DISCUSSION

Cleaning and shaping of root canals is one of the main steps in achieving endodontic success. It includes removal of vital and necrotic tissues along with infected root dentin, which gives the canal system a shape that allows easy debridement and placement of medicaments and permanent root filling of high technical quality[37]. To achieve this goal, clinicians must have adequate knowledge of root canal anatomy of the relevant tooth and its common variations. The main mechanical objectives of the canal preparation is to maintain the adequate canal geometry, with continuous tapering funnel, with apical foramen as small as possible. There are various anatomic complexities which represent physical constraints that pose serious challenge to adequate root canal disinfection. Latrou classified root canals depending on the cross-section shape as: laminar or tubular (Latrou 1980)[32]. Laminar canals can be further divided into semilunar, 'figure of 8' or straight, whilst tubular canals may becircular, triangular or oval.

Metrically Jou *et al*. (2004)[31] defined ''oval''shape as having a maximum diameter of up to two times greater than the minimum diameter and ''long oval'' as having a maximum diameter of two to four times greater than the minimum diameter.A high prevalence of oval and long oval root canals found in mandibular incisors and maxillary second premolars. According to Wu *et al*. (2000)[59], long oval canals occur in the apical portion in about 25% of cases. Mauger *et al*. (1998)[41] showed that after resecting the

apices of mandibular incisors at a 20-degree facial bevel, the average facio-lingual diameter of canals was 0.75 mm at a distance of 3 mm from the apex. They found that oval canals contributed 42% and long oval canals 40% towards the findings of the study. It can be speculated that most canals of mandibular incisors are not round in shape.

Traditionally stainless steel instruments have been used to enlarge the root canal to atleast three ISO sizes larger than the first file to bind at the apical part of the canal. The inherent stiffness of Stainless steel produces iatrogenic damage in the form of ledge, perforation, canal transportation and straightening in curved canals.In case of Long-oval–shaped canals shaping with hand files proved to be a significant challenge[38]. This led to increased research over last two decades in the manufacturing of endodontic instruments. By the introduction of rotary instruments in 1988 there was a clinical breakthrough in endodontics to overcome the challenges faced by stainless steel instrumentation. The unique characteristics of NiTi files are super elasticity and shape memory.Rotary systems are mostly preferred by clinicians because of their advantage such as saving time and better cutting efficiency. They offer many advantages by facilitating endodontic procedures to be carried out in less time, minimizing procedural errors and maintaining original canal shape. These rotary systems consists of multiple file sequences for canal preparation which is time consuming and eventually removes more dentin[40]. Nevertheless some functions of NiTi rotary systems such as cleaning ability increased stress, inability to adequately prepare oval canals are still

controversial. Cimilli and Kartal demonstrated that the continuous rotation movement tends to shift the center of the preparation in a clockwise direction[9].Wu et al reported that continuous rotary motion in flat oval canal causes substantial untouched areas (35% - 45%)left on the buccal and lingual sides or on the side facing the isthumus in tear shaped canal[60]. Kim et al reported the potential relationship between design of NiTi instruments and the incidence of vertical root fractures. Hand and rotary instruments working in reaming motion have been reported to leave untouched fins or recesses. In addition harbouring remnants of pulp tissue or bacterial biofilms, such recesses might also be packed with dentin chips generated and pushed there in by rotating instruments[40.]

To overcome the difficulties faced by continuous rotary motion in oval shaped canals, there was a constant quest, which led to the introduction of Reciprocating System and SAF system[39].The reciprocating files is an evolution of balanced force concept. It is made of M wire technology, a proprietary thermo-mechanical processes. M wire is a special NiTi alloy with increased flexibility and improved resistance to cyclic fatigue when compared to conventional NiTi files. The reciprocating systems (Reciproc, WaveOne, WaveOne Gold) uses single file that has the advantage of cutting less dentin and being less invasive by increasing canal centering. Wave One reciprocating instruments are designed to work with a reverse cutting action. All instruments have a modified convex triangular cross-section at the tip end and a convex triangular cross-section at the coronal end. This design improves instrument

flexibility overall. The tips are modified to follow canal curvature accurately. The variable pitch flutes along the length of the instrument considerably improve safety. The pre-programmed motor is set for the angles of reciprocation and speed for WaveOne instruments. The counterclockwise (CCW) movement is greater than the clockwise (CW) movement. CCW movement advancesthe instrument, engaging and cutting the dentine. CW movement dis engages the instrument from the dentine before it can (taper) lock into the canal[23].

There are three files in the WaveOne single-file reciprocating system available in lengths of 21, 25 and 31mm

1. The WaveOne Small file is used in fine canals. The tip size is ISO 21 with a continuous taper of 6%.
2. The WaveOne Primary file is used in the majority of canals. The tip size is ISO 25 with an apical taper of 8% that reduces towards the coronal end.
3. The WaveOne Large file is used in large canals. The tip size is ISO 40 with an apical taper of 8% that reduces towards the coronal end.

Riitano F et al[49] concluded that WaveOne system with reciprocating motion decreases the remaining amount of untouched areas (20%-35%). Hence, in this present study Wave One single-file reciprocating system was used.

In addition to the reciprocating system, An innovative instrument SAF system was introduced. The SAF is a hollow file designed as a compressible,

thin-walled pointed cylinder either 1.5 or 2.0 mm in diameter composed of 120-mm-thick nickel-titanium lattice. The 1.5-mm file may easily be compressed to the extent of being inserted into any canal previously prepared or negotiated with a # 20 K-file. The 2.0-mmfile will easily compress into a canal that was prepared with a #30 K-file.The file will then attempt to regain its original dimensions, thus applying a constant delicate pressure on the canal walls. When inserted into a root canal, it adapts itself to the canal's shape, both longitudinally (as well any nickel titanium file) and along the cross-section. In a round canal, it will attain a round cross-section, whereas in an oval or flat canal it will attain a flat or oval cross-section, providing a three-dimensional adaptation. The surface of the lattice threads is lightly abrasive, which allows it to remove dentin with a back-and-forth grinding motion[39].The SAF is operated with transline (in and out) vibrating handpiece with 3,000 to 5,000 vibrations per minute and an amplitude of 0.4mm. Such a handpiece may be the KaVo GENTLE power or equivalent combined with either a 3LDSY head (360_ free rotation; Kavo, BiberachRiss Germany) or MK-Dent head (360_ free rotation; MK-Dent,Bargteheide, Germany) or RDT3 head (80 rpm when free and stops rotating when engaging the canal walls, recently developed by Re-Dent-Nova, Raanana, Israel). The vibrating movement combined with intimate contact along the entire circumference and length of the canal removes a layer of dentin with a grinding motion[38].

The hollow design allows for continuous irrigation throughout the procedure. A special irrigation device (VATEA, ReDent-Nova) is connected

by a silicon tube to the irrigation hub on the file and provides continuous flow of the irrigant of choice at a lowpressure and at flow rates of 1 to 10 mL/min. Alternatively, any physio dispenser type of irrigation device that is primarily designed for implantology may also be used[37].

The SAF is inserted into the canal while vibrating and is delicately pushed in until it reaches the predetermined working length. It is then operated with in-and-out manual motion and with continuous irrigation using two cycles of 2 minutes each for a total of 4 minutes per canal. This procedure will remove a uniform dentin layer 60- to 75-mm thick from the canal circumference. The SAF file is designed for single use.

The SAF file is different from any current nickel-titanium rotary file. Most rotary file systems will find the widest part of the canal and gradually machine it, using several files of increasing diameter, to a wider canal with a round cross section. If the canal happens to be relatively narrow, the whole original canal may be included in the preparation. However, if the canal is flat, oval, tear shaped, or simply large, this mode of preparation may leave untreated recesses, mainly buccally or lingually to the machined part of the canal.[38]

The SAF is used as a single file (of either 1.5- or 2.0-mm diameter) that starts as a narrow, compressed, shape and gradually expands in the canal while removing a uniform layer of dentin from its walls. Because the file adapts itself to the cross-section of a given canal, a canal with a round cross-section is enlarged as a round canal, whereas an oval canal is enlarged as an

oval canal of larger dimensions. High-resolution three-dimensional micro-CT analysis showed that high percentage (83.2%) of the canal wall is affected by the SAF file even in oval flat root canals[48], hence present study self adjusting file system was used.

Metzer et al[38] concluded SAF system decreases substantial amount of untouched areas to about 17%. .Siqueria et al[51] defined SAF system as a cleaning shaping, irrigation system because it performs simultaneous chemomechanical preparation and cleaning of root canal space.

Root canal obturation is an essential stage of root canal treatment aimed to seal the root canal three dimensionally, in order to prevent future bacterial contamination/recontamination of the canal space. Many obturation methods have been introduced over the years,each attempting to provide a better seal of the root canal. If the root canal is not adequately prepared and tissue remnants and debris are present along the walls, proper sealing may be jeopardized, even with the best root canal filling method.

Gutta-percha is the most popular solid core material used for obturation , it composed of 20%gutta-percha, 65%zinc oxide,10% radio opacifiers and 5% plasticizer, antimicrobial properties are enhanced by adding iodoform, calcium, chlorhexidine, Alpha phase is commonly used in warm vertical/thermoplastized obturation technique and beta form in cold lateral condensation technique . It does not bind or attach to the dentin root canal walls. In order to obtain some form of hydraulic closure of the root canal system,a sealing agent must be employed[60].

Root canal sealer is used to seal the space between dentinal walls and obturating core materials. It is also used to fill the voids, canal irregularities in lateral canals and accessory canals and space between GP points used in lateral compaction. It serves as a lubricants during obturation process. Zinc oxide-eugenol sealers has been most commonly used for sealing root canals, it was introduced by ricket and Dixon, later grossman modified the formulation. It sets in moist or humid environment by forming chelation compound within 24 hours, altered by addition of resins, calcium phosphates or zinc acetate. Hence in this study Zinc oxide eugenol sealer is used[60].Many obturation methods are used today, ranging from traditional lateral compaction to a variety of heat-softened gutta-percha techniques.

Cold lateral compaction is a traditional method for obturation. The technique can be used in most clinical situations and provides for predictable length control during compaction.Selection of master cone should be similar to master apical file size with the tug back and it is notched at the working distance.[67] Minimal judicious force should be used on the spreader during the compaction process in order to avoid root fractures.The size of the spreader is determined by width of the prepared canal and lateral fit of the primary cone. The greater the space between the canal wall and the butt end of the guttapercha, the larger spreader used[66].The spreader size should reach within 1 to 2 mm of working length in order to obtain apical compaction. This can be ensured by placing a silicon stopper on the spreader. Additional secondary cones are inserted until the spreader cannot penetrate beyond the cervical line.

A cement coating is not mandatory for secondary cones[68]. The limitations of lateral compaction technique does not produce homogenous mass since the cones are laminated and remain separate. So there is presence of voids in between the master cone and accessory cones with an increased sealer guttapercha ratio, and does not fill canal irregularities compared with thermo plastic technique[60].

To overcome the drawbacks thermoplastized obturation technique was developed. It involves heating of guttapercha outside the tooth and injecting the material in to the canal resulting in a more homogenous mass of guttapercha than lateral compaction. There are various thermoplastic systems available such as Obtura II, Calamus, Elements, Hotshot, Ultrafil 3D, Obtura III. Elements obturating unit incorporates advanced technologies involving software, metallurgy, electronics and industrial design with best elements of system B and a patent pending motorized extruder with disposable catridges. It consist of various modes from down-pack to back fil. The catridges comes with the 20, 23, 25 gauge needle for GP[67]. The handpiece of the extruder is very smaller than other devices, this streamlined design and the extra needle length provide unprecedented visibility for greater control and accuracy. The apical terminus should be smaller as possible to prevent extrusion of guttapercha. Hence, In this study Elements Obuturating Unit was used for thermoplastized obturation technique[67].

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There are various methods to evaluate the obturation quality such as Computed Tomography, Cone Beam Computed Tomography, Micro-Computed Tomography. In this present study, CT imaging was used to evaluate the obturation quality in oval shaped canals due to its cost-effectiveness. Here, we have used the recent software named IPL (version 1.01) SVCT (version 1.0) which enables to visualize the images in different colour codes differentiating the pre and post images.

Computed tomography (CT) was introduced by sir GodfreyHounsfield 1970's. Tomography refers to tomograph "Slicing imaging" in which thin slices of the anatomy of the interest are captured and synthesized manually or using the algorithm. Computed Tomogrphy makes use of automated reconstruction[18]. Computed Tomography (CT) is an imaging technique where digital geometry processing can be used to generate a 3D-image of tissue and structures obtained from a large series of 2D X-ray images. X-ray scans furnish detailed images of an object such as dimensions, shape, internal defects and density for diagnostic and research purposes[18].

Three important parameters of computed tomographic imaging are described in following sections.

- Voxel size
- Field of view
- Slice thickness and measurement accuracy

Voxels are cuboidal elements that constitute a 3D volume, unlike pixels,which are 2D.data are acquired and represented in three dimentional

using voxels.Computed tomographic units acquire x-ray information using low kV and low mA exposure parameters in a single pass from 180 to 360 degree rotation around the anatomy of the interest. These voxel sizes can be small as 0.076 to 0.6mm[67.]

The field of view ranges from as small as a portion of a dental arch to an area as large as the entire head. The selection of the FOV depends on several factors. Among the most important are the following

- Diagnostic task
- Type of patient
- Spatial resolution requirements

  Use of computed tomography must be determined on case by case basis only.

According to American Association of Endodontics (AAA) and the American Acadamy of Oral and Maxillofacial Radiology (AAOMR), list indications for potential use in selected cases, including evalution of the anatomy and complex morphology, differential diagnosis of complex pathogenesis with certain qualifiers, intra operative and post operative assessment of endodontic treatment, dentoalveolar trauma, resorption, presurgical case planning and dental case implant planning[67].

Image processing and data analysis were performed by using ImageJ Adobe Photoshop 7.0, Corel PHOTO-PAINT 12.0 and OriginPro 7.5 software. ImageJ is a public domain Java image processing program suitable to measure distances and angles, to calculate area and pixel value statistics of user-defined

selections and to provide density histograms and line profile plots. Adobe Photoshop 7.0 image processing software has been used in conjunction with Corel PHOTO-PAINT 12.0 programs to improve the CT images by adjusting and creating special effects[18].

Hence, Computed tomography imaging was done to evaluate the obturation quality in oval shaped canals using SAF system and WaveOne system by Computed tomography imaging.

60 extracted human mandibular premolar were collected and kept in 10% buffered formalin, teeth were selected based on root canal morphology and immersed in 3%sodium hypochlorite and their external surfaces were carefully cleaned of calculus and debris with the help of ultrasonic scaler and washed under running water. Teeth were decoronated , and roots were standardized using a diamond disk operated at low speed to 15 mm in length .ISO size # 10 k file was inserted into root canal until just visible at apical foramen . Working length of each root canal was them established 1 mm short of the apical foramen. Each apex was sealed using sticky wax to stimulate the clinical situation. All the procedures were perfomed by a single operator.

The 60 samples were then divided into 2 experimental Groups, Group A (SAF) (n=30) and Group B (WaveOne) (n=30) respectively. Each Group further divided in to 2 subgroups based on obturation techniques namely cold lateral compaction and thermoplastized obturation technique.

Group A

SAF system were used for chemomechanical preparation. SAF (ReDent) was operated for 4 minutes using a GentlePowerLux 20LP KaVohandpiece, (KaVo, Biberach, Germany) adapted with a RDT3 hea**d (ReDent-Nova, Raanana, Israel)**. The micromotar rotation speed was set at 5000 rpm, which resulted in and out operation of 5000 vibration per minute with amplitude of 0.4mm. The file was used with manual in and out motion to the working length. Continuous irrigation was applied throughout the procedure at 5mL/min using a special irrigation apparatus (VATEA irrigation device, part of the SAF system ReDent). 3 % NaOCl used for irrigation during the first three minutes of operation followed by one minutes of irrigation with 17% EDTA. A final flush with 5 ml 3%NaOCl was used to remove EDTA, and the canal was dried using paper points.

Group B

Wave One large files were used. WaveOne motor is rechargeable battery operated with a 6:1 reducing handpiece. WaveOne file large (ISO 040.08) was used to prepare the teeth with brushing and gentle inward stroking motion with short 2-3mm amplitude strokes , irrigation was done with 2.5 ml of 3 % NaOCl and 17%EDTA.

CT images were obtained after the cleaning and shaping procedure of the root canals with SAF systemand wave one system

Versaini et al[54] reported SAF had significantly more contact to dentin walls and removed more debris than rotary instrumentation in the apical third of mandibular incisor. Metzger et al[39] demonstrated that the operation of the

SAF system with continuous irrigation coupled with alternating sodium hypochlorite and EDTA treatment resulted in a clean and mostly smear layer–free dentinal surface in all parts of the root canal. Siqueira et al[51] showed that the SAF system was significantly more effective than rotary NiTi instrumentation used with syringe/needle irrigation in disinfecting long oval root canals in vitro.De-Deus et al[16] conducted a histologic comparison of the debridement efficacy of the SAF system with the ProTaper system and demonstrated that the SAF system was more efficient in pulpal debridement. Studies of Paque and Peters et al[45], Versiani et al[54] showed that shapes generated with the SAF were more complete compared with rotary canal preparation.

Further, these groups were subdivided in to two groups with 15 teeth respectively.In SAF group, 15 teeth were obturated with cold lateral compaction and 15 teeth were obturated with thermoplastized gutta percha . The same method of obturation was followed in wave one system.

The obturated teeth were then subjected to Computed Tomography and then the images were super imposed with the images obtained with cleaning and shaping. And the data were analysed using newly developed software IPL (version 1.01), SVCT (version 1.0) to evaluate the quality of the obturation of the samples.

Results were subjected to statistical analysis using Statistical Package for Social Sciences software (SPSS version 19, USA). The present study aimed to evaluate the quality of obturation in oval shaped canals after using

two rotary systems the SAF system and WaveOne system with two different obturation technique namely called cold lateral compaction and thermoplastized guttapercha technique. The quality of the oburation for both the groups was assessed under Computer Tomography image. When the thermoplastized technique was compared among SAF system and WaveOne system groups there was statistically significant difference with a p value of 0.001.

While the cold lateral compaction was compared in the SAF and WaveOne systems there was statistically significant difference among them with a p value of 0.001.

In the present study, The mean value obtained for thermoplastized obturation technique in SAF system was 3% and Wave One system was 23% which showed that the ability of SAF cleaning-shaping-irrigation system improved both shaping and cleaning of oval- shaped root canals compared with SAF system than the NiTi rotary files. A higher percentage of the canal wall was affected by instrumentation with SAF method than with rotary files, less tissue debris is left after instrumentation and almost no packing of hard-tissue particles occurs. The canal preparation with the SAF system improved the filling ability with a thermoplastized obturation technique, which was in accordance with Gustavo de-deus et al[16] who concluded that instrumentation of flat oval canals with SAF system led to significantly higher percentage guttapercha filled area compared with rotary systems. Metzger et al[39],

concluded that SAF allowed better cleaning and shaping and better adaptation of root canal filling than those allowed by rotary files.

Under the limitation of this study, it can be concluded that SAF system showed better obturation quality when compared with WaveOne system. This is due to the ability of SAF system to form closer contact with the canal walls, even in the buccal and lingual recesses that were commonly unaffected by the rotary files.

Summary

SUMMARY

The purpose of this study was to evaluate obturation quality in teeth with oval shaped canals, prepared with SAF system and WaveOne system with two obturation techniques cold lateral compaction and thermoplastized obturation technique.

Sixty extracted human mandibular incisor teeth were randomly selected which met the inclusion and exclusion criteria. To standardize canal instrumentation, teeth were decoronated by using diamond disc.

The teeth were scanned with the help of CT to visualize the root morphology and were divided into two groups with 30 teeth each and they were further subdivided into two groups consisting of 15 teeth respectively, After which cleaning and shaping was done followed by CT scans.

In Group A, 30 teeth were prepared with SAF system and in Group B , 30 teeth were prepared with waveone system and both groups were obturated with two obturation techniques, cold lateral compaction technique (n=15) and thermoplastized technique (n=15).

Final images were taken with CT scan to evaluate the quality of obturation in both the groups.

The obturated teeth were then subjected to CT and then the images were super imposed with the images obtained from cleaning and shaping. And the data were analysed using software IPL (version 1.01), SVCT (version1.0).

Results were subjected to statistical analysis using Statistical Package for Social Sciences software (SPSS version 19, USA). Normality was checked using Shapiro-Wilk test. All the data were found to be normal in distribution. Hence, parametric test was used. All comparisons were done using Student t test.

1. The present study revealed that in the SAF group there was statistically significant difference among the thermoplastized obturation technique and cold lateral compaction technique.
2. In the WaveOne group there was statistically significant difference among thermoplastized obturation technique and cold lateral compaction.
3. Among the groups both the thermoplastized obturation technique and cold lateral compaction technique of SAF group showed significant difference compared to WaveOne group.

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Conclusion

CONCLUSION

- Teeth prepared with SAF system had better cleaning and shaping ability of oval canals compared with Wave One system.
- Teeth samples prepared with SAF system showed better obturation quality compare with Wave One system
- Thermoplastized obturation technique proved to have better obturation quality than cold lateral compaction technique assessed by computed tomographic image.
- Thermoplastized obturation technique done with SAF system in the oval shaped canals showed better obturation quality compared with Wave One system.
- It can be concluded that oval shaped canals can achieve better obturation quality with thermoplastized obturation technique using SAF system.
- It was concluded that there was high percentage of gutta-percha filled area in SAF system compared with Wave One system.

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TO WHOMSOEVER IT MAY CONCERN

DATE: 05/01/2017

From

The Institutional Ethics Board,

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The dissertation topic titled **"EVALUATION OF OBTURATION QUALITY IN OVAL SHAPED CANALS USING SAF SYSTEM AND WAVE ONE SYSTEM BY COMPUTED TOMOGRAPHY- AN INVITRO STUDY"** submitted by **Dr. Sathish.S** has been approved by the Institutional Ethics Board of Ragas Dental College and Hospital.

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